US007798434B2

(12) United States Patent
Bondeson et al.

(10) Patent No.: US 7,798,434 B2
(45) Date of Patent: Sep. 21, 2010

(54) **MULTI-PLATE NOZZLE AND METHOD FOR DISPENSING RANDOM PATTERN OF ADHESIVE FILAMENTS**

(75) Inventors: **Benjamin J. Bondeson**, Suwanee, GA (US); **Thomas Burmester**, Bleckede (DE); **Hubert Kufner**, Luneburg (DE); **Joel E. Saine**, Dahlonega, GA (US)

(73) Assignee: **Nordson Corporation**, Westlake, OH (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 951 days.

(21) Appl. No.: **11/610,148**

(22) Filed: **Dec. 13, 2006**

(65) **Prior Publication Data**

US 2008/0145530 A1 Jun. 19, 2008

(51) **Int. Cl.**

B05B 1/28	(2006.01)
B05B 7/10	(2006.01)
B05B 1/14	(2006.01)
B05B 1/26	(2006.01)
F23D 14/68	(2006.01)
A62C 31/02	(2006.01)

(52) **U.S. Cl.** **239/601**; 239/296; 239/299; 239/406; 239/553; 239/553.3; 239/553.5; 239/590.3

(58) **Field of Classification Search** 239/290, 239/294, 295, 296, 298, 299, 406, 548, 549, 239/552, 553, 553.3, 553.5, 555, 556, 557, 239/561, 568, 590.3, 601; 427/207.1, 208.6, 427/286; 118/313, 315

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2,031,387 A 2/1936 Schwarz

(Continued)

FOREIGN PATENT DOCUMENTS

DE 3543469 A1 12/1985

(Continued)

OTHER PUBLICATIONS

Rajiv S. Rao et al., Vibration and Stability in the Melt Blowing Process, Ind. Eng. Chem. Res., 1993, 32, 3100-3111.

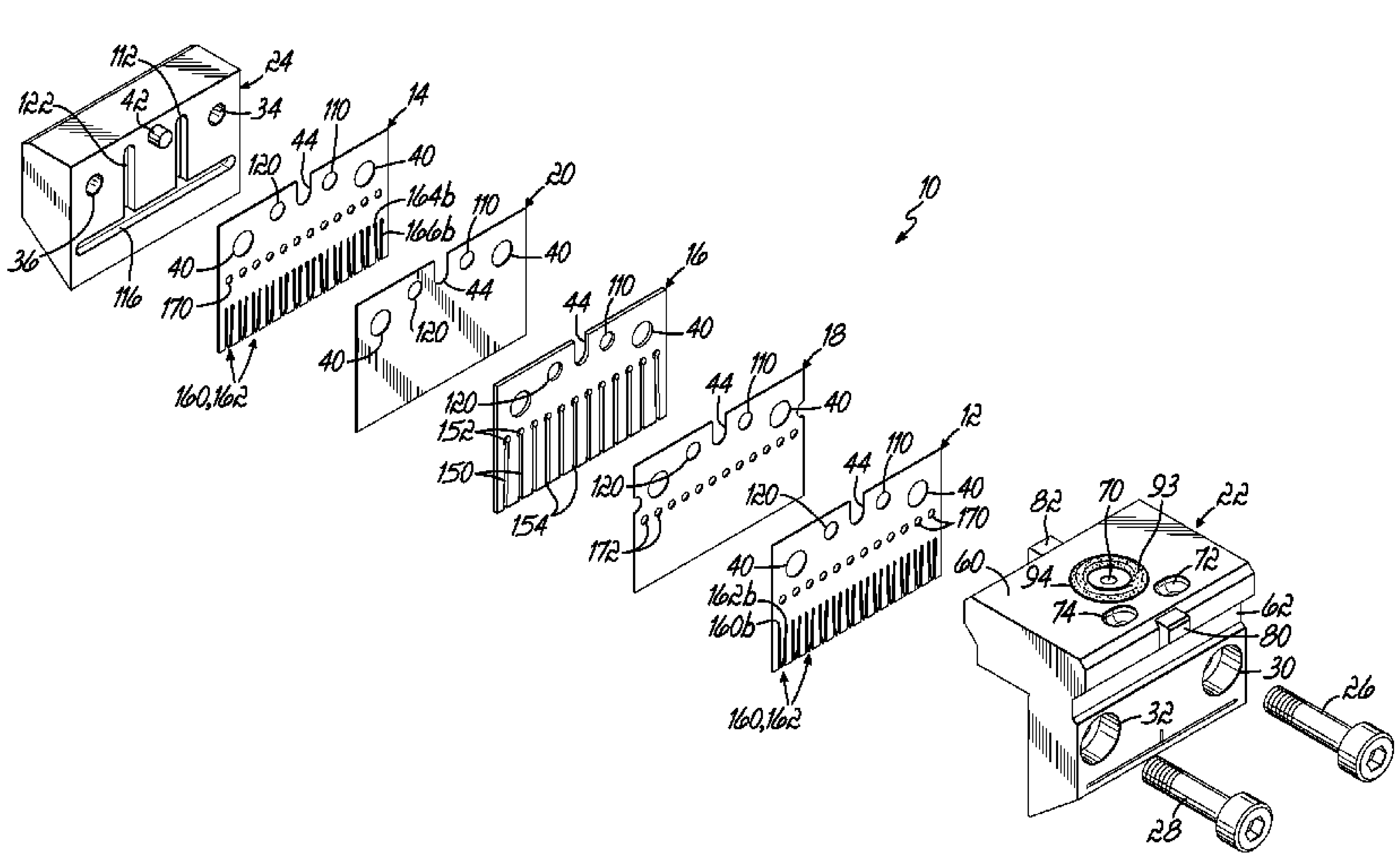
(Continued)

Primary Examiner—Dinh Q Nguyen
Assistant Examiner—Ryan Reis
(74) *Attorney, Agent, or Firm*—Wood, Herron & Evans, L.L.P.

(57) **ABSTRACT**

A nozzle for dispensing a random pattern of liquid adhesive filaments. The nozzle may include first and second air shim plates, an adhesive shim plate and first and second separating shim plates. The first and second air shim plates each have respective pairs of air slots. Each air slot has a process air inlet and a process air outlet and the air slots of each pair converge toward one another such that the process air inlets are farther apart than the process air outlets in each pair. The adhesive shim plate includes a plurality of liquid slots each with a liquid outlet. Four process air outlets are associated with each of the liquid outlets. The process air slots are adapted to receive pressurized process air and the liquid slots are adapted to receive pressurized liquid adhesive. The pressurized process air discharges from each group of the four process air outlets and forms a zone of turbulence for moving the filament of liquid adhesive discharging from the associated liquid outlet in a random pattern.

6 Claims, 7 Drawing Sheets



U.S. PATENT DOCUMENTS

2,212,448	A	8/1940	Modigliani
2,297,726	A	10/1942	Stephanoff
2,628,386	A	2/1953	Tornberg
3,032,008	A	5/1962	Land et al.
3,038,202	A	6/1962	Harkenrider
3,176,345	A	4/1965	Powell
3,178,770	A	4/1965	Willis
3,181,738	A	5/1965	Hartvig-Johansen
3,192,562	A	7/1965	Powell
3,192,563	A	7/1965	Crompton
3,204,290	A *	9/1965	Crompton 425/190
3,213,170	A	10/1965	Erdmenger et al.
3,253,301	A	5/1966	McGlaughlin
3,334,792	A	8/1967	Vries et al.
3,379,811	A	4/1968	Hartmann et al.
3,380,128	A	4/1968	Cremer et al.
3,488,806	A	1/1970	De Cecco et al.
3,492,692	A	2/1970	Soda et al.
3,501,805	A	3/1970	Douglas, Jr. et al.
3,613,170	A	10/1971	Soda et al.
3,650,866	A	3/1972	Prentice
3,704,198	A	11/1972	Prentice
3,730,662	A	5/1973	Nunning
3,755,527	A	8/1973	Keller et al.
3,801,400	A	4/1974	Vogt et al.
3,803,951	A	4/1974	Bagley
3,806,289	A	4/1974	Schwarz
3,807,917	A	4/1974	Shimoda et al.
3,825,379	A	7/1974	Lohkamp et al.
3,847,537	A	11/1974	Velie
3,849,241	A	11/1974	Butin et al.
3,852,013	A	12/1974	Upmeier
3,861,850	A	1/1975	Wallis
3,874,886	A	4/1975	Levecque et al.
3,888,610	A	6/1975	Brackmann et al.
3,920,362	A	11/1975	Bradt
3,923,444	A	12/1975	Esper et al.
3,942,723	A	3/1976	Langdon
3,954,361	A	5/1976	Page
3,970,417	A	7/1976	Page
3,978,185	A	8/1976	Buntin et al.
3,981,650	A	9/1976	Page
4,007,625	A	2/1977	Houben et al.
4,015,963	A	4/1977	Levecque et al.
4,015,964	A	4/1977	Levecque et al.
4,050,866	A	9/1977	Kilsdonk
4,052,002	A	10/1977	Stouffer et al.
4,052,183	A	10/1977	Levecque et al.
4,100,324	A	7/1978	Anderson et al.
4,145,173	A	3/1979	Pelzer et al.
4,151,955	A	5/1979	Stouffer
4,185,981	A	1/1980	Ohsato et al.
4,189,455	A	2/1980	Raganato et al.
4,277,436	A	7/1981	Shah et al.
4,300,876	A	11/1981	Kane et al.
4,340,563	A	7/1982	Appel et al.
4,359,445	A	11/1982	Kane et al.
4,380,570	A	4/1983	Schwarz
4,414,276	A	11/1983	Kiriyama et al.
4,457,685	A	7/1984	Huang et al.
4,468,366	A	8/1984	Socha, Jr.
4,526,733	A	7/1985	Lau
4,548,632	A	10/1985	Tanaka et al.
4,568,506	A	2/1986	Kiriyama et al.
4,596,364	A	6/1986	Bauer
4,645,444	A	2/1987	Lenk et al.
4,652,225	A	3/1987	Dehennau et al.
4,694,992	A	9/1987	Stouffer
4,708,619	A	11/1987	Balk
4,709,836	A	12/1987	Andersen
4,711,683	A	12/1987	Merkatoris
4,730,197	A	3/1988	Raman et al.
4,746,283	A	5/1988	Hobson
4,747,986	A	5/1988	Chao
4,774,109	A	9/1988	Hadzimihalis et al.
4,785,996	A	11/1988	Ziecker et al.
4,812,276	A	3/1989	Chao
4,818,463	A	4/1989	Buehning
4,818,464	A	4/1989	Lau
4,826,415	A	5/1989	Mende
4,842,666	A	6/1989	Werenicz
4,844,003	A	7/1989	Slautterback et al.
4,874,451	A	10/1989	Boger et al.
4,875,844	A	10/1989	Nakajima et al.
4,889,476	A	12/1989	Buehning
RE33,158	E	2/1990	Stouffer et al.
RE33,159	E	2/1990	Bauer
4,905,909	A	3/1990	Woods
4,918,017	A	4/1990	Greenstreet et al.
4,923,706	A	5/1990	Binley et al.
4,949,668	A	8/1990	Heindel et al.
4,955,547	A	9/1990	Woods
4,960,619	A	10/1990	Slautterback et al.
RE33,448	E	11/1990	Bauer
RE33,481	E	12/1990	Ziecker et al.
4,983,109	A	1/1991	Miller et al.
5,013,232	A	5/1991	Way
5,017,116	A	5/1991	Carter et al.
5,035,361	A	7/1991	Stouffer
5,066,435	A	11/1991	Lorenz et al.
5,067,885	A	11/1991	Stevenson et al.
5,069,853	A	12/1991	Miller
5,094,792	A	3/1992	Baran
5,098,636	A	3/1992	Balk
5,114,752	A	5/1992	Hall
5,124,111	A	6/1992	Keller et al.
5,129,585	A	7/1992	Bauer
5,145,689	A	9/1992	Allen et al.
5,147,197	A	9/1992	Hodan et al.
5,160,746	A	11/1992	Dodge, II et al.
5,165,940	A	11/1992	Windley
5,169,071	A	12/1992	Boger et al.
5,209,410	A	5/1993	Wichmann et al.
5,234,650	A	8/1993	Hagen et al.
5,242,644	A	9/1993	Thompson et al.
5,260,003	A	11/1993	Nyssen et al.
5,269,670	A	12/1993	Allen et al.
5,275,676	A	1/1994	Rooyakkers et al.
5,312,500	A	5/1994	Kurihara et al.
5,342,647	A	8/1994	Heindel et al.
5,354,378	A	10/1994	Hauser et al.
5,393,219	A	2/1995	Hagen et al.
5,397,227	A	3/1995	Hodan et al.
5,407,619	A	4/1995	Maeda et al.
5,409,733	A	4/1995	Boger et al.
5,418,009	A	5/1995	Raterman et al.
5,421,921	A	6/1995	Gill et al.
5,421,941	A	6/1995	Allen et al.
5,423,935	A	6/1995	Benecke et al.
5,429,840	A	7/1995	Raterman et al.
5,445,509	A	8/1995	Allen et al.
5,458,291	A	10/1995	Brusko et al.
5,458,721	A	10/1995	Raterman
5,476,616	A	12/1995	Schwarz
5,478,224	A	12/1995	McGuffey
D367,865	S	3/1996	Bajadali
5,503,784	A	4/1996	Balk
5,512,793	A	4/1996	Takeuchi et al.
5,524,828	A	6/1996	Raterman et al.
5,533,675	A	7/1996	Benecke et al.
5,540,804	A	7/1996	Raterman
5,551,588	A	9/1996	Hills
5,605,706	A	2/1997	Allen et al.
5,618,347	A	4/1997	Clare et al.

5,618,566	A	4/1997	Allen et al.	
5,620,139	A	4/1997	Ziecker	
5,620,664	A	4/1997	Palmer	
5,645,790	A	7/1997	Schwarz et al.	
5,667,750	A	9/1997	Nohr et al.	
5,679,379	A	10/1997	Fabbricante et al.	
5,902,540	A	5/1999	Kwok	
5,904,298	A *	5/1999	Kwok et al.	239/135
5,927,560	A	7/1999	Lewis et al.	
5,964,973	A	10/1999	Heath et al.	
5,992,688	A	11/1999	Lewis et al.	
D420,099	S	2/2000	Lewis et al.	
6,051,180	A *	4/2000	Kwok	264/555
6,074,597	A	6/2000	Kwok et al.	
D429,263	S	8/2000	Auber et al.	
6,235,137	B1	5/2001	Van Eperen et al.	
6,264,113	B1	7/2001	Dingler	
D456,427	S	4/2002	Gressett, Jr. et al.	
6,375,099	B1 *	4/2002	McGuffey	239/553.5
D457,538	S	5/2002	Gressett, Jr. et al.	
D460,092	S	7/2002	Gressett, Jr. et al.	
D461,483	S	8/2002	Gressett, Jr. et al.	
6,540,152	B2	4/2003	Holm et al.	
6,578,773	B2	6/2003	Holm et al.	
6,676,038	B2	1/2004	Gressett, Jr. et al.	
6,680,021	B1	1/2004	Kwok et al.	
6,890,167	B1	5/2005	Kwok et al.	
6,938,795	B2	9/2005	Barton, Jr. et al.	
D519,536	S	4/2006	de Leeuw et al.	
D520,538	S	5/2006	de Leeuw et al.	
D521,035	S	5/2006	de Leeuw et al.	
D524,833	S	7/2006	Folk et al.	
D529,321	S	10/2006	Gould et al.	
D536,354	S	2/2007	Kufner et al.	
D550,261	S	9/2007	Bondeson et al.	
2005/0205689	A1	9/2005	Crane et al.	
2009/0258138	A1	10/2009	Burmester et al.	

FOREIGN PATENT DOCUMENTS

DE	19715740	A1	4/1997
EP	0893517	A2	1/1999
EP	0979885	A2	2/2000
EP	1155745	A2	11/2001
EP	0835952	B1	2/2003
EP	0872580	B1	6/2005
GB	756907		9/1956
GB	1392667		4/1975
WO	9207122	A1	4/1992
WO	9315895	A1	8/1993
WO	9904950	A1	2/1999

OTHER PUBLICATIONS

Gregory F. Ward, Micro-Denier Nonwoven Process and Fabrics, on or about Oct. 17, 1997, pp. 1-9.

Scott R. Miller, Beyond Meltblowing: Process Refinement in Microfibre Hot Melt Adhesive Technology, Edana 1998 International Nonwovens Symposium, 11 pgs.

European Patent Office, European Search Report in EP Application No. 07122920, Aug. 27, 2008.

Today's Idea, Nordson Unveils Diaper Elastic System, Oct. 1988, 1 pg.

Nordson Corporation, Adhesive and Powder Application Systems for the Nonwoven Industry, 1992, 7 pgs.

Edward K. McNalley et al., J&M Laboratories, Durafiber/Durastitch Adhesives Applications Methods Featuring Solid State Application Technology disclosed Sep. 8, 1997 at Inda-Tec 97 Meeting, Cambridge MA, pp. 26.1-26-8.

* cited by examiner

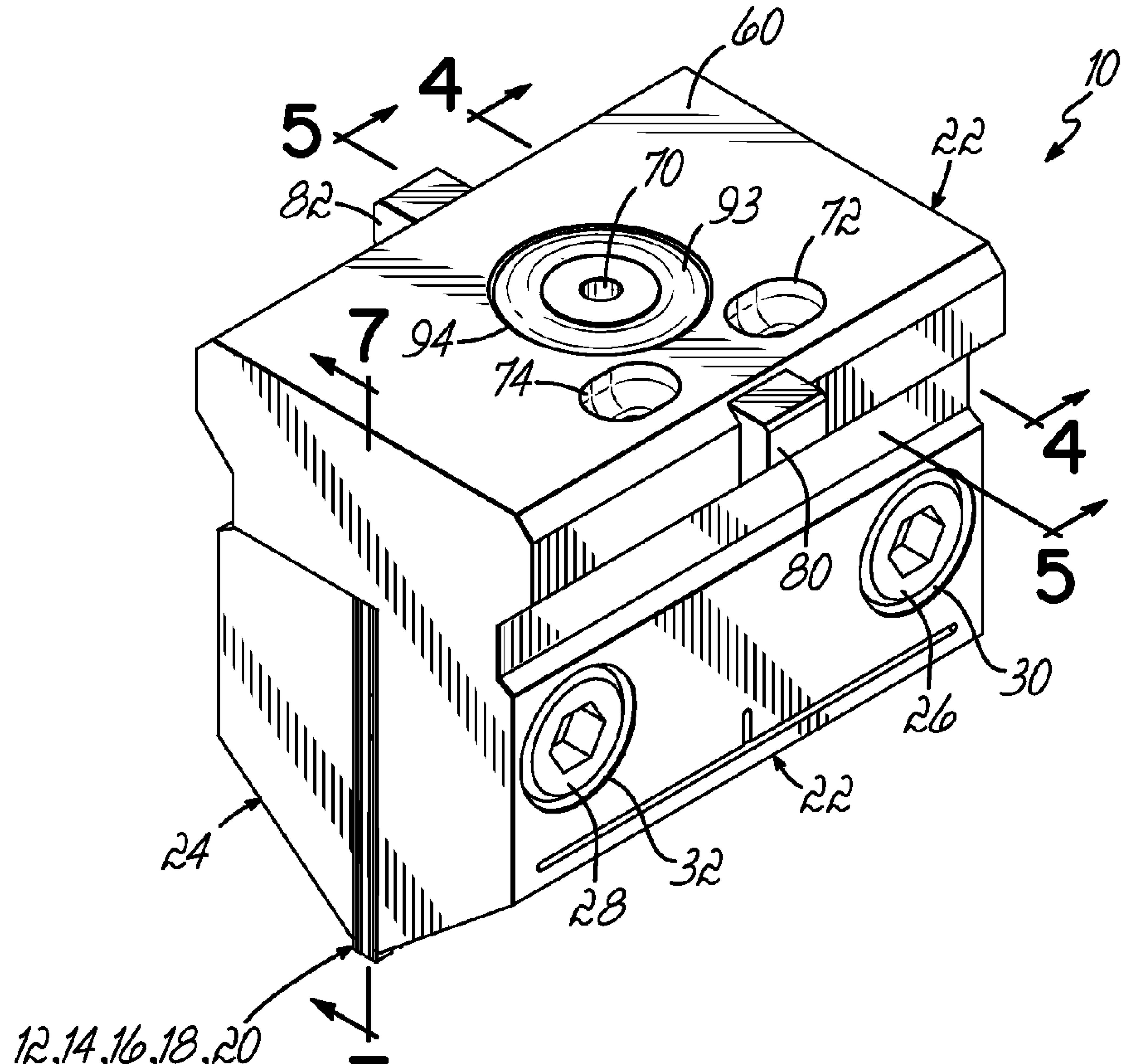

60
10
5
4
22
82
70
93
72
7
94
74
4
80
5
30
26
22
24
28
32
12,14,16,18,20
7

FIG. 1

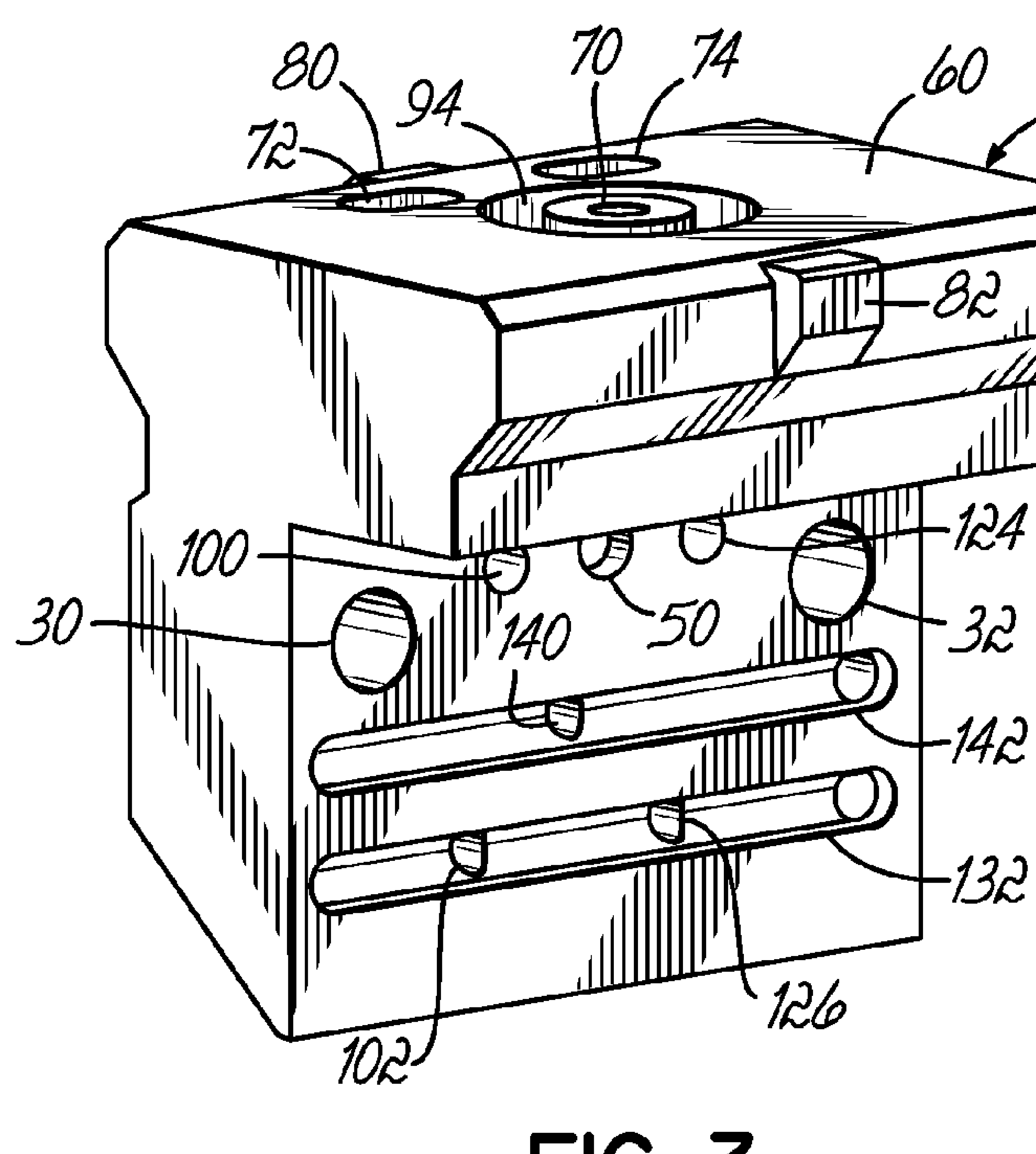

80
70
74
60
22
72
94
82
100
124
30
50
32
140
142
132
102
126

FIG. 3

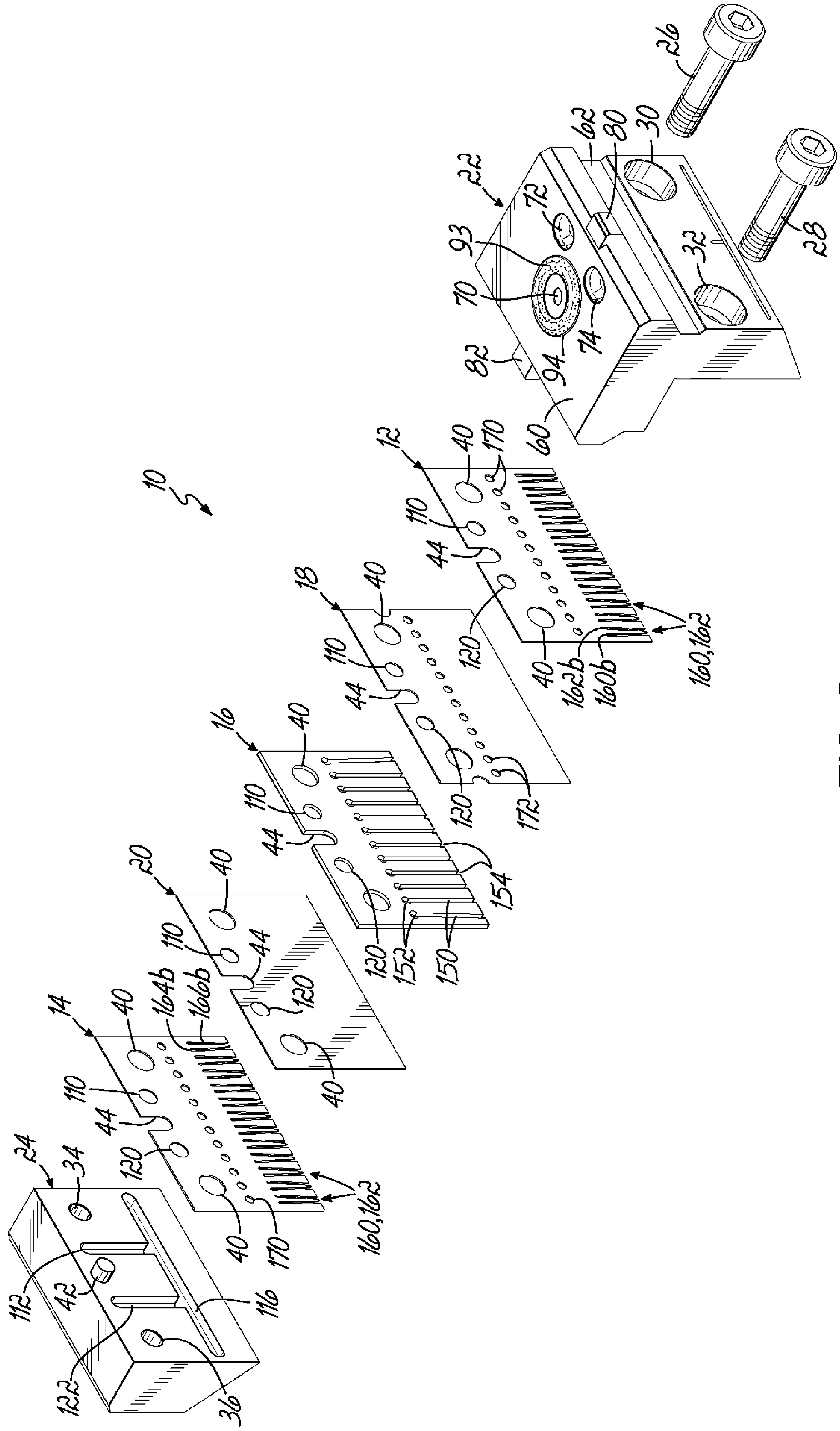
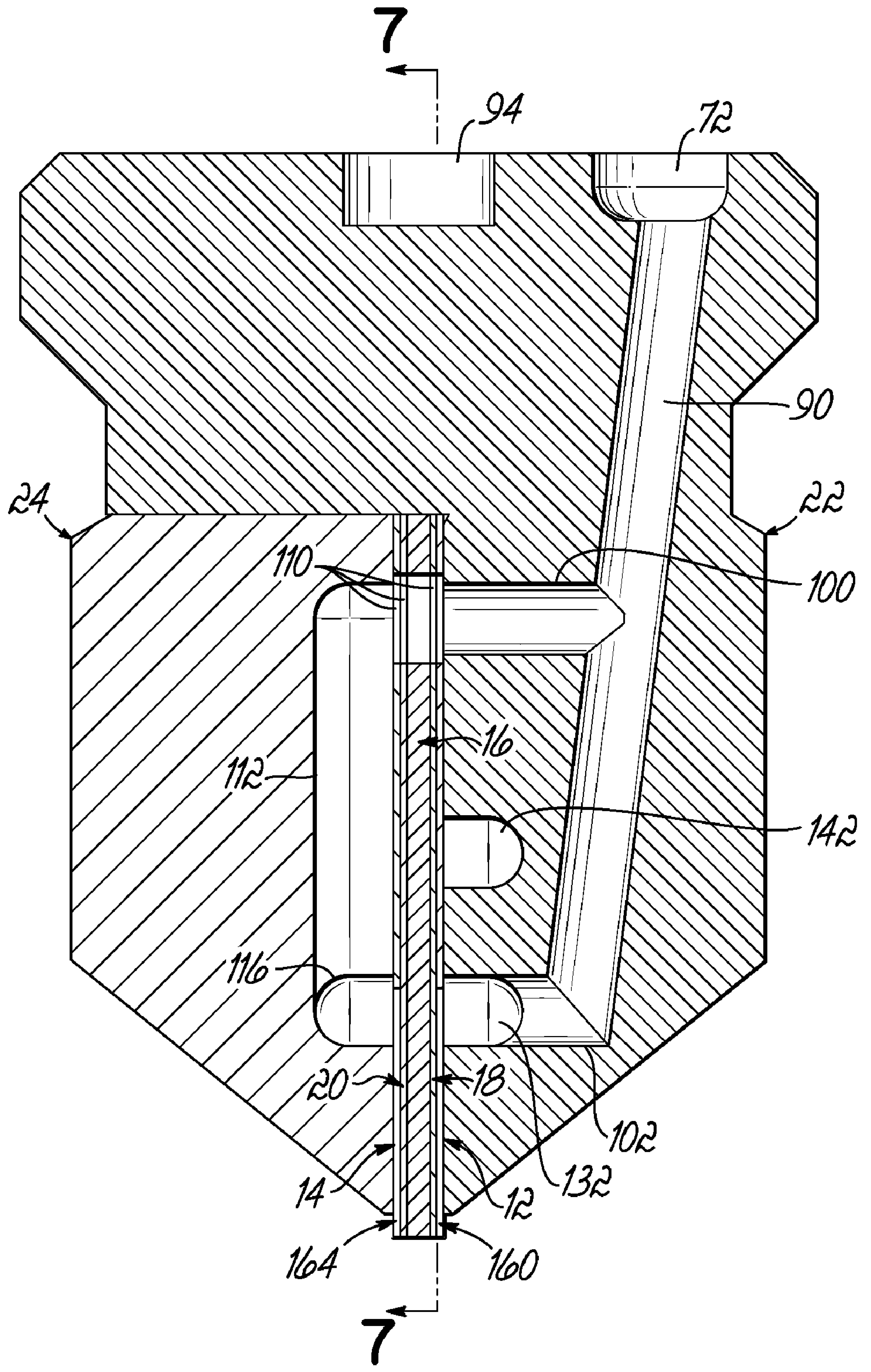

10
12
14
16
18
20
22
24
26
28
30
32
34
36
40
42
44
60
62
70
72
74
80
82
93
94
110
112
116
120
122
150
152
154
160,162
160b
162b
164b
170
172

FIG. 2



7
7
10
94
72
90
24
22
110
100
16
112
142
116
20
18
102
132
14
12
164
160

FIG. 4

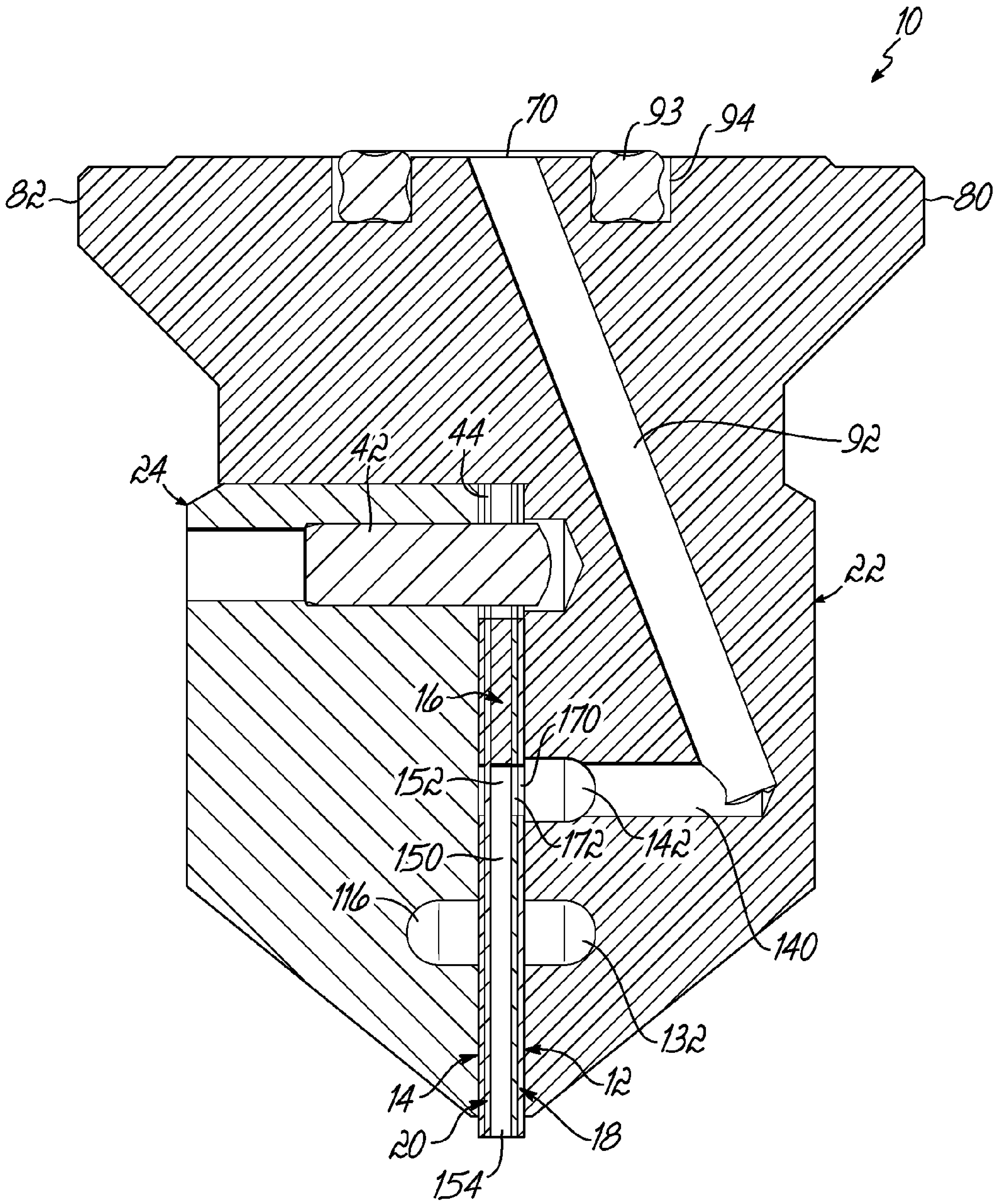

10
70
93
94
82
80
92
24
42
44
22
16
170
152
172
142
150
140
116
132
14
12
20
18
154

FIG. 5

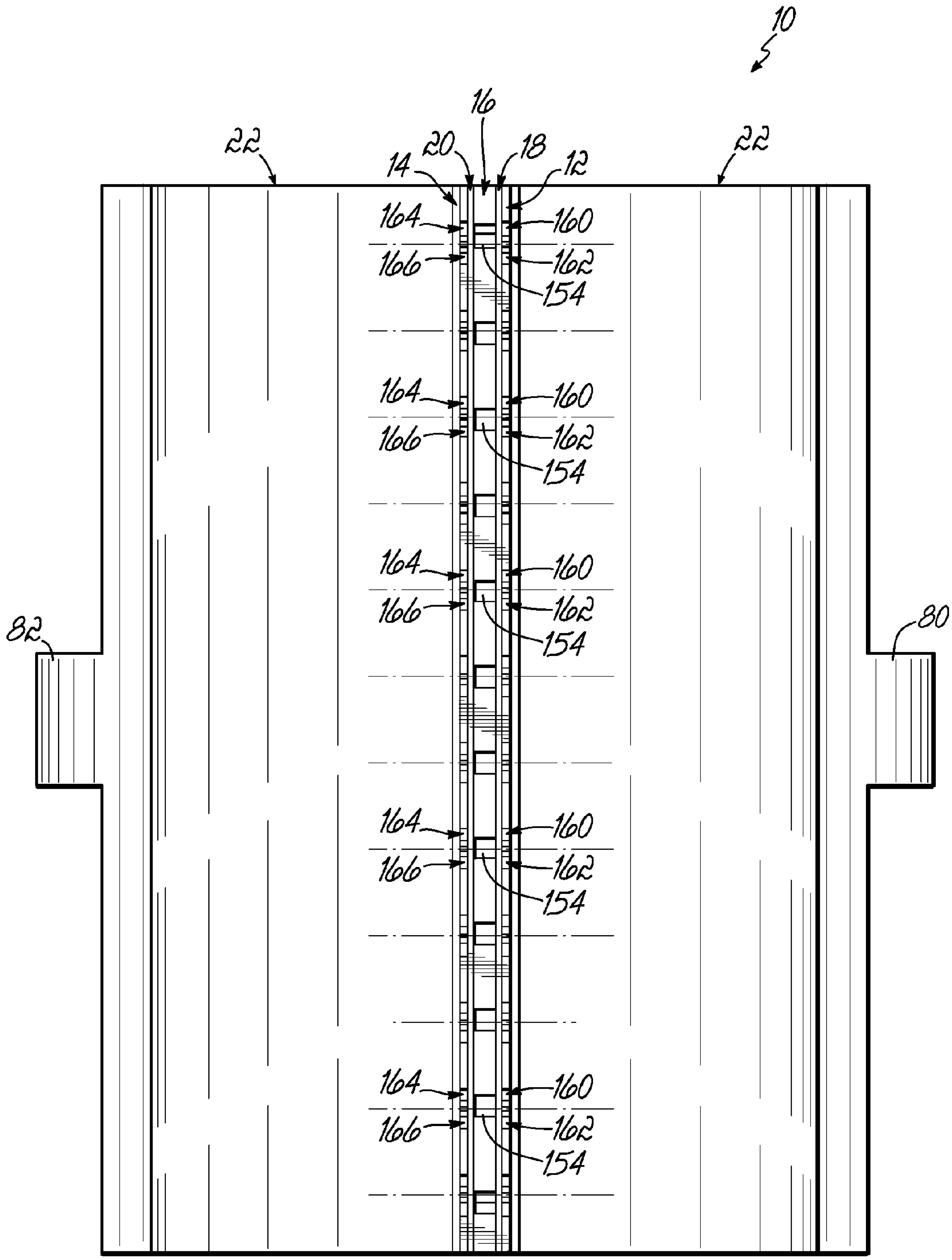

10
16
22
20
18
22
14
12
164
160
166
162
154
164
160
166
162
154
164
160
166
162
154
82
80
164
160
166
162
154
164
160
166
162
154

FIG. 6

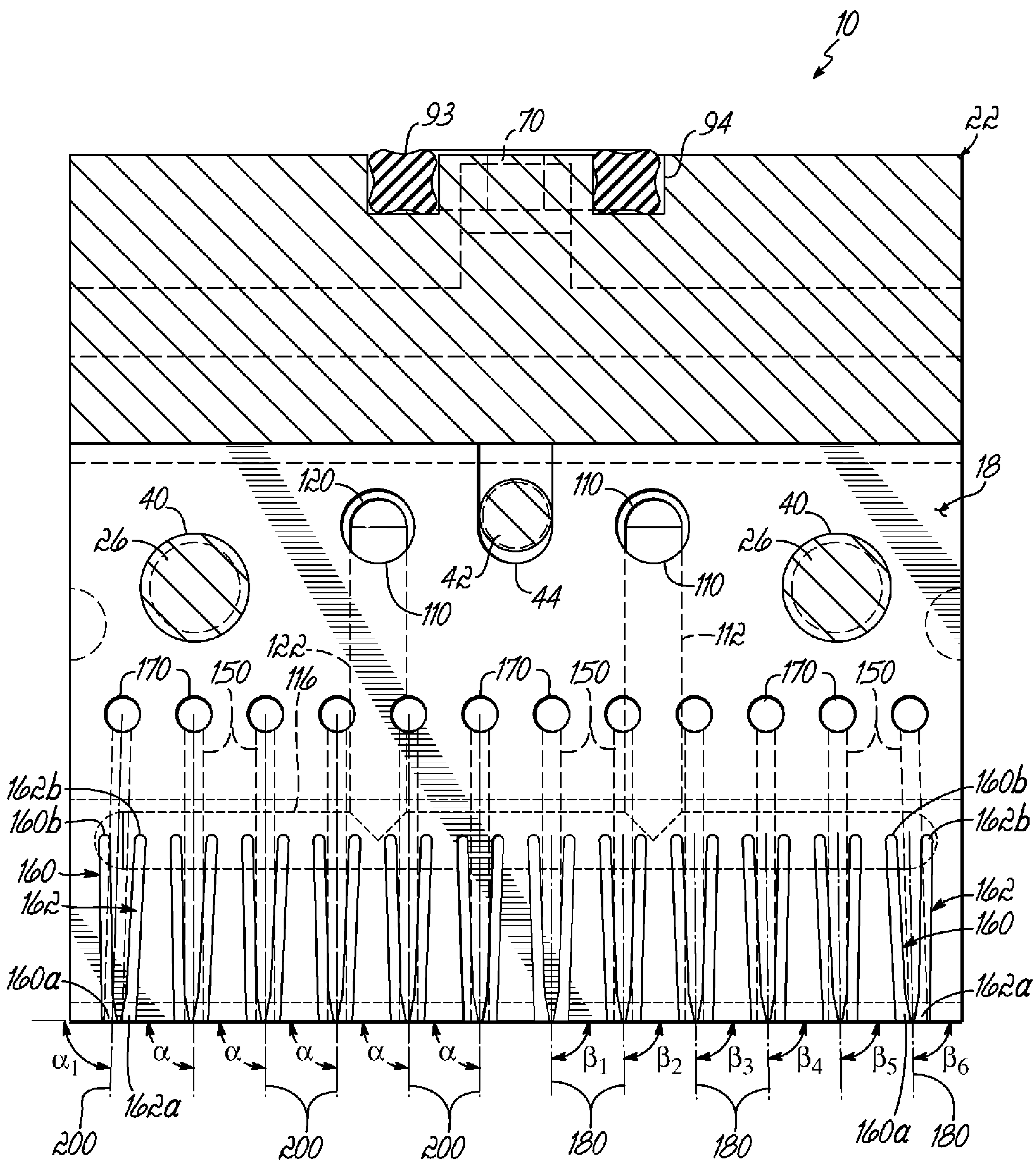

10
93
70
94
22
18
120
110
40
26
42
44
112
122
116
170
150
162b
160b
160
162
160a
162a
α1
α
β1
β2
β3
β4
β5
β6
200
180

FIG. 7

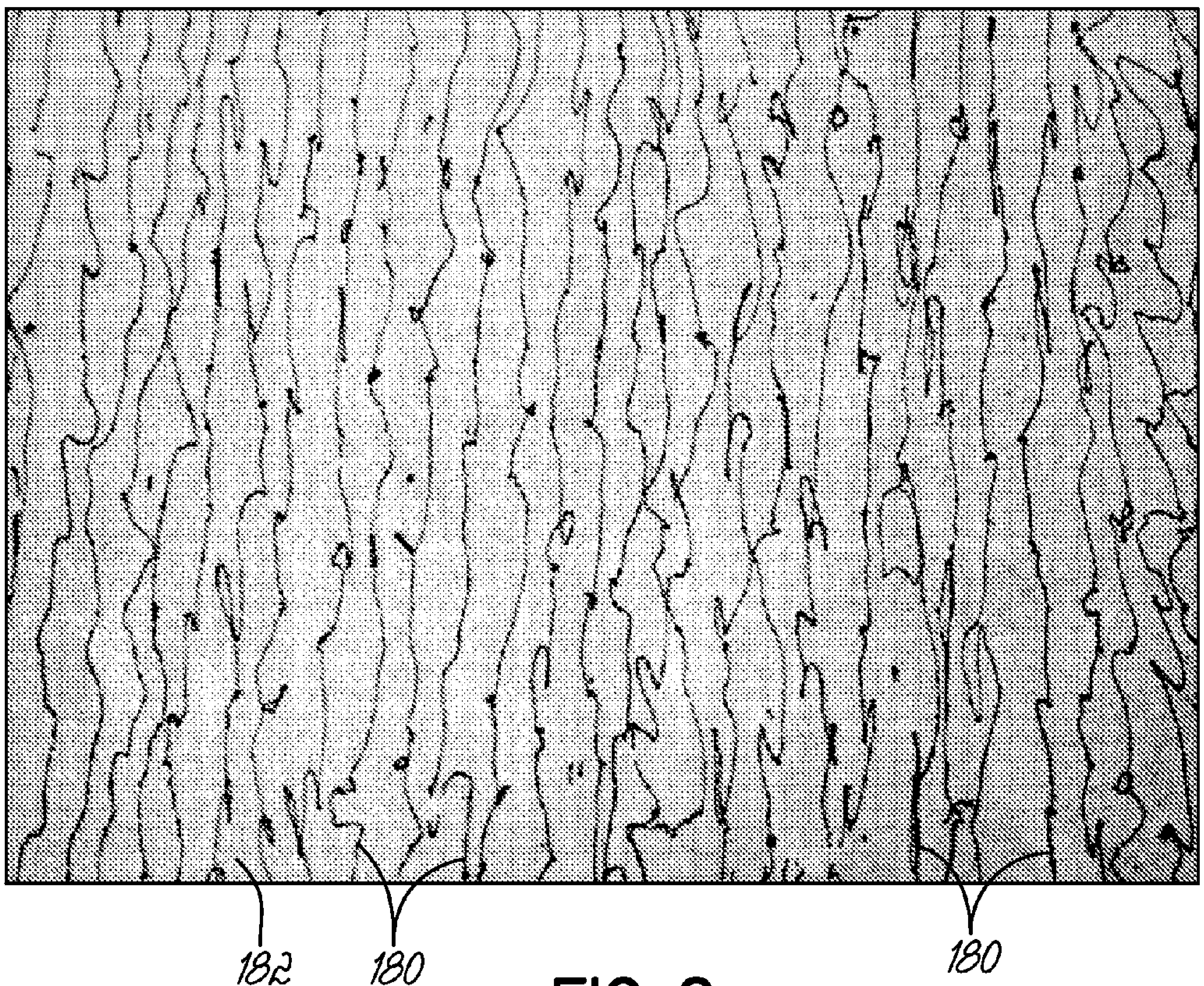


FIG. 8

MULTI-PLATE NOZZLE AND METHOD FOR DISPENSING RANDOM PATTERN OF ADHESIVE FILAMENTS

TECHNICAL FIELD

The present invention relates generally to air-assisted nozzles and systems for extruding and moving filaments of viscous liquid in desired patterns and, more particularly, air-assisted dispensing of hot melt adhesive filaments.

BACKGROUND

Various dispensing systems have been used in the past for applying patterns of viscous liquid material, such as hot melt adhesives, onto a moving substrate. In the production of disposable diapers, incontinence pads and similar articles, for example, hot melt adhesive dispensing systems have been developed for applying a laminating or bonding layer of hot melt thermoplastic adhesive between a nonwoven fibrous layer and a thin polyethylene backsheet. Typically, the hot melt adhesive dispensing system is mounted above a moving polyethylene backsheet layer and applies a uniform pattern of hot melt adhesive material across the upper surface width of the backsheet substrate. Downstream of the dispensing system, a nonwoven layer is laminated to the polyethylene layer through a pressure nip and then further processed into a final usable product.

In various known hot melt adhesive dispensing systems, continuous filaments of adhesive are emitted from a multiple adhesive outlet die with multiple process air jets oriented in various configurations adjacent the circumference of each adhesive outlet. The multiple air jets discharge air generally tangentially relative to the orientation of the discharged adhesive filament or fiber as the filament emerges from the die orifice. This process air can generally attenuate each adhesive filament and cause the filaments to move back and forth in overlapping or non-overlapping patterns before being deposited on the upper surface of the moving substrate.

Manufacturers of diaper products and others remain interested in small fiber technology for the bonding layer of hot melt adhesive in nonwoven and polyethylene sheet laminates. To this end, hot melt adhesive dispensing systems have incorporated slot nozzle dies with a pair of angled air channels formed on either side of the elongated extrusion slot of the die. As the hot melt adhesive emits from the extrusion slot as a continuous sheet or curtain, pressurized process air is emitted as a pair of curtains from the air channels to impinge upon, attenuate and fiberize the adhesive curtain to form a uniform fibrous web of adhesive on the substrate. Fibrous web adhesive dispensers have incorporated intermittent control of adhesive and air flows to form discrete patterns of fibrous adhesive layers with well defined cut-on and cut-off edges and well defined side edges.

Meltblown technology has also been adapted for use in this area to produce a hot melt adhesive bonding layer having fibers of relatively small diameter. Meltblown dies typically include a series of closely spaced adhesive nozzles or orifices that are aligned on a common axis across the die head. A pair of angled air channels or individual air passages and orifices are positioned on both sides of the adhesive nozzles or orifices and align parallel to the common nozzle axis. As hot melt adhesive discharges from the series of aligned nozzles or orifices, pressurized process air is discharged from the air channels or orifices and attenuates the adhesive fibers or filaments before they are applied to the moving substrate.

While meltblown technology has been used to produce fibrous adhesive layers on moving substrates, it has various areas in need of improvement. As those skilled in the art will appreciate, meltblown technology typically uses a high volume of high velocity air to draw down and attenuate the emitted adhesive filaments. The high velocity air causes the fibers to oscillate in a plane that is generally aligned with the movement of the substrate, i.e., in the machine direction. To adequately blend adjacent patterns of adhesive to form a uniform layer on the substrate, meltblown dispensers require the nozzles to be closely spaced. Moreover, the volume and velocity of the air must be high enough to sufficiently agitate and blend adjacent fibers.

However, the high volume of air used in conventional meltblown dispensers adds to the overall operational cost as well as reduces the ability to control the pattern of emitted fibers. One byproduct of the high velocity air is "fly" in which the fibers get blown away from the desired deposition pattern. The "fly" can be deposited either outside the desired edges of the pattern, or even build up on the dispensing equipment which can cause operational problems that require significant maintenance. Another byproduct of the high velocity air and closely spaced nozzles is "shot" in which adjacent adhesive fibers become entangled and form globules of adhesive on the backsheet substrate. "Shot" is undesirable as it can cause heat distortion of the delicate polyethylene backsheet.

It will be further appreciated by those skilled in the art that when typical meltblown dies are placed in side-by-side fashion across the width of a moving substrate a less consistent fiber pattern on the substrate results. This occurs since each meltblown die has continuous sheets of air formed on either side and these sheets of air are interrupted between adjacent meltblown dies.

Other air-assisted nozzles or dies use capillary style tubes mounted in a nozzle or die body for extruding filaments of thermoplastic material. Air passages are provided adjacent to the tubes, and the ends of the tubes project outwardly relative to the outlets of the air passages.

Various forms of laminated plate technology are known for extruding rows of adhesive filaments in an air assisted manner. These include dispensing nozzles or dies constructed with slotted plates for discharging filaments of liquid and process or pattern air for attenuating and moving the discharged filaments in a desired pattern. These nozzles or dies present various issues relating to their performance, design complexity and large numbers of plates needed to complete the assembly. Therefore, improvements remain needed in this area of technology.

SUMMARY

The present invention, in an illustrative embodiment, provides a nozzle for dispensing a random pattern of liquid adhesive filaments. The nozzle includes first and second air shim plates, an adhesive shim plate and first and second separating shim plates. The first and second air shim plates each have respective pairs of air slots. Each air slot has a process air inlet and a process air outlet and the air slots of each pair converge toward one another such that the process air inlets are farther apart than the process air outlets in each pair. The adhesive shim plate includes a plurality of liquid slots each with a liquid inlet and a liquid outlet. The adhesive shim plate is positioned between and lies parallel to the first and second process air shim plates such that one of the liquid slots extends generally centrally between a pair of the air slots in the first process air shim plate and a pair of the air slots in the second process air shim plate. In this manner, four process air outlets are associated with each of the liquid outlets. The process air slots are adapted to receive pressurized process air and the liquid slots are adapted to receive pressurized liquid adhesive. The pressurized process air discharges from each group of the four process air outlets and forms a zone of turbulence for moving the filament of liquid adhesive discharging from the associated liquid outlet in a random pattern. The nozzle further includes first and second end plates securing together and sandwiching the first and second process air shim plates, the adhesive shim plate and the first and second separating shim plates. The first end plate includes a process air inlet communicating with the pairs of air slots in the first and second process air shim plates and a liquid adhesive inlet communicating with the liquid slots in the adhesive shim plate.

Various additional features are incorporated into the illustrative embodiment of the nozzle. For example, the first and second process air shim plates have first and second opposite ends and the pairs of process air slots respectively angle in a progressive manner outwardly from a central portion of each process air shim plate toward the opposite ends of the process air shim plates. This assists with spreading the pattern of adhesive filaments outwardly in opposite directions along the width of the nozzle. The adhesive shim plate also includes opposite ends and at least the liquid slots closest to the opposite ends of the adhesive shim plate respectively angle outwardly toward the opposite ends. This may assist with spreading the adhesive filament pattern in opposite directions.

In the illustrative embodiment, the first and second end plates further comprise respective process air passages for directing pressurized process air between the first and second end plates. The first end plate is generally L-shaped and includes a top surface generally orthogonal to planes containing the first and second process air shim plates, the adhesive shim plate and the first and second separating shim plates, and a side surface generally parallel to the planes containing the first and second process air shim plates, the adhesive shim plate and the first and second separating shim plates. The liquid adhesive inlet and the process air inlet are formed in the top surface.

The invention further contemplates methods directed generally to the manner in which liquid filaments and process air are discharged to form a random pattern of filaments on a substrate.

Various additional features and advantages of the invention will become more readily apparent to those of ordinary skill in the art upon review of the following detailed description of the illustrative embodiment taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is an assembled perspective view of a nozzle constructed in accordance with an illustrative embodiment of the invention.

FIG. **2** is a disassembled perspective view of the nozzle shown in FIG. **1**.

FIG. **3** is a perspective view the inside of an end plate of the nozzle shown in FIG. **1**.

FIG. **4** is a cross sectional view taken along line **4-4** of FIG. **1**.

FIG. **5** is a cross sectional view taken along line **5-5** of FIG. **1**.

FIG. **6** is a bottom view of the nozzle shown in FIG. **1**.

FIG. **7** is a cross sectional view generally taken along lines **7-7** of FIGS. **1** and **4**.

FIG. **8** is an elevational view of a random filament pattern produced with a nozzle constructed in accordance with the principles discussed herein.

DETAILED DESCRIPTION OF THE ILLUSTRATIVE EMBODIMENTS

Referring first to FIGS. **1** and **2**, a nozzle **10** in accordance with one illustrative embodiment is shown and generally includes first and second process air shim plates **12**, **14**, an adhesive shim plate **16**, first and second separating shim plates **18**, **20**, and first and second end plates **22**, **24**. The entire assembly is held together as shown in FIG. **1** by, for example, a pair of threaded fasteners **26**, **28** that extend through holes **30**, **32** in the first end plate **22** and into threaded holes **34**, **36** in the second end plate **24**. As further shown in FIG. **2**, respective holes **40** in the air shim plates **12**, **14**, separating shim plates **18**, **20** and adhesive shim plate **16** allow passage of the threaded fasteners **26**, **28** as well. The second end plate **24** includes a projection **42** serving as a locating member that extends through respective upper slots **44** in the air shim plates **12**, **14**, separating shim plates **18**, **20**, and adhesive shim plate **16**. The projection or locating member **42** is then received in a blind bore **50** (FIG. **3**) in the first end plate **22**.

The first end plate **22** is a generally L-shaped member and includes a top surface **60** generally orthogonal to planes that contain the first and second process air shim plates **12**, **14**, the adhesive shim plate **16** and the first and second separating shim plates **18**, **20**. A side surface **62** generally parallel to the planes containing these same shim plates receives the threaded fasteners **26**, **28**. The top surface **60** includes an adhesive inlet **70** and a pair of process air inlets **72**, **74**. The first end plate **22** also includes oppositely extending projections **80**, **82** that may be used for securing the nozzle **10** to a dispensing valve or module (not shown) as further shown and described in U.S. Pat. No. 6,676,038, the disclosure of which is hereby incorporated by reference herein.

Referring to FIGS. **2-5**, the first end plate **22** includes a process air inlet passage **90** (FIG. **4**) communicating with the inlet **72** and a liquid adhesive inlet passage **92** (FIG. **5**) communicating with the liquid inlet **70**. A seal member **93** located in a groove **94** may be used to seal liquid inlet **70**. As also shown in FIG. **4**, the process air inlet passage **90** communicates with first and second air distribution passages **100**, **102** that respectively communicate with opposite sides of the shim plate assembly **12**, **14**, **16**, **18**, **20**. It will be appreciated that a second identical distribution passage system (not shown) in the first end plate **22** communicates with the second air inlet **74** (FIG. **2**) to provide additional pressurized air to opposite sides of shim plate assembly **12**, **14**, **16**, **18**, **20**. The upper distribution passage **100** passes through the shim plate assembly **12**, **14**, **16**, **18**, **20** through aligned holes **110** and through a vertical recess **112** (FIGS. **2** and **4**) and, finally, into a horizontally extending slot **116** in the second end plate **24**. Another series of aligned holes **120** and another vertical recess **122** are provided to receive process air from the other air inlet **74** through the previously mentioned identical distribution passage system. In this regard, distribution passages **124**, **126** shown in FIG. **3** communicate with air inlet **74**. Passage **124** aligns with holes **120** and slot **122** shown in FIG. **2**, while passage **126** communicates with recess **132** as shown in FIG. **3**. The horizontally extending slot **116** communicates with one side of the shim plate assembly, as discussed further below. The other distribution passage **102** communicates with a lower horizontal recess **132** contained in the first end plate (FIGS. **3** and **4**). This horizontal recess **132** communicates with the right side of the shim plate assembly (as viewed in

FIG. **4**) for supplying process air to the first process air shim plate **12**. As shown in FIG. **5**, the liquid inlet passage **92** communicates with a liquid distribution passage **140** and an upper horizontal slot **142** (FIG. **3**) in the first end plate **22**. This upper horizontal slot **142** communicates with the adhesive shim plate **16** as further described below.

Again referring to FIG. **2**, the adhesive shim plate **16** includes a plurality of liquid slots **150** each with a liquid inlet **152** and a liquid outlet **154**. The adhesive shim plate **16** is positioned between and lies parallel to the first and second process air shim plates **12**, **14** such that one of the liquid slots **150** extends generally centrally between a first pair of air slots **160**, **162** in the first process air shim plate **12** and also generally centrally between a second pair of the air slots **164**, **166** in the second process air shim plate **14**. As best viewed in FIG. **7**, each first pair of air slots **160**, **162** is directly aligned with a corresponding second pair of air slots **164**, **166** (not shown in FIG. **7**), although the pairs of air slots **160**, **162** and **164**, **166** are separated by adhesive shim plate **16** and separating shim plates **18**, **20**. Thus, as shown in FIG. **6**, four process air outlets **160***a*, **162***a*, **164***a*, **166***a* are associated with each of the liquid outlets **154**. As further shown in FIGS. **2** and **7**, air slots **160**, **162** converge toward each other and air slots **164**, **166** converge toward each other such that the process air inlets **160***b*, **162***b* and **164***b*, **166***b* are farther apart than the corresponding process air outlets **160***a*, **162***a* and **164***a*, **166***a* in each pair. However, none of the air slots **160**, **162**, **164**, **166** converge toward their associated liquid slot **150** since the respective pairs of slots **160**, **162** and **164**, **166** are each contained in parallel planes different from the plane containing he liquid slots **150**. From a review of FIG. **7**, it will be appreciated that for each of the liquid slots **150**, one pair of converging process air slots **160**, **162** is shown and another pair is hidden behind the first pair but is directly aligned therewith in the second process air shim plate **14**.

In the manner previously described, pressurized process air is directed downwardly through the respective pairs of slots **160**, **162** and **164**, **166** in both process air shim plates **12**, **14**. In this regard, the horizontal slot **132** communicates pressurized air to the inlets **160***b*, **162***b* of slots **160**, **162** in the first process air shim plate **12**. The horizontal slot **116** communicates pressurized air to the inlets **164***b*, **166***b* of the slots **164**, **166** in the second process air shim plate **14**. Liquid hot melt adhesive is directed into the liquid inlet passage **70** to the distribution passage **140** and the upper horizontal slot **142** in the first end plate **22**. The upper horizontal slot **142** in the first end plate **22** communicates with respective aligned holes **170**, **172** in the first process air shim plate **12** and the first separating shim plate **18** and, finally, into the upper inlets **152** of the liquid slots **150**. The second process air shim plate **14** also includes such holes **170** to allow full interchangeability between the first and second process air shim plates **12**, **14**. In the construction shown in FIG. **2**, the holes **170** in the second process air shim plate **14** remain unused. The separating shim plates **18**, **20** are utilized to seal off the respective air slots **160**, **162** and **164**, **166** from the liquid slots **150**.

Nozzle **10** has a design such that it may be flipped or rotated 180° from left to right when mounting to a valve module (not shown). Furthermore, the respective liquid slots **150** and air slots **160**, **162**, **164**, **166** may be formed along any desired width or width portion(s) of the respective air shim plates **12**, **14** and adhesive shim plate **16** depending on the needs of the application. The air shim plates may always have the full distribution of air slots **160**, **162**, **164**, **166** as shown for nozzle **10** since providing additional air streams typically will not adversely affect the discharged filaments.

As further shown in FIG. **7**, twelve respective groupings of 1) pairs of air slots **160**, **162**, 2) pairs of air slots **164**, **166** (FIG. **2**) and 3) individual liquid slots **150** are shown in the illustrative embodiment. The right hand side of FIG. **7** illustrates respective centerlines **180** centered between the respective pairs of converging air slots **160**, **162**. These air slot centerlines and, therefore, the respective pairs of air slots **160**, **162** gradually angle toward an outer end of the process air shim plate **12**. Thus, for example, the angles of the respective centerlines **180** may gradually become smaller relative to horizontal with β_1 being the largest angle at 90° and β_6 being the smallest angle at 87.5°. In this illustrative embodiment, the angles may, for example, be as follows:

β_1=90°

β_2=89.5°

β_3=89°

β_4=88.5°

β_5=88°

β_6=87.5°

Of course, other angles may be chosen instead, depending on application needs. The second process air shim plate **14** may be configured in an identical manner.

On the left hand side of FIG. **7**, additional centerlines **200** are shown through the respective centers of the liquid slots **150**. In this embodiment, angle α may be 90°, while angle α_1 may be less than 90°, such as 88.3°. In this manner, the outermost or endmost liquid slot **150** is angled outwardly toward the outer edge of the shim plate **16**. The outermost liquid slot **150** on the opposite edge of the assembly may also include this feature. Likewise, the respective six pairs of process air slots **160**, **162** on the left hand side of FIG. **7** may also be gradually fanned (as pairs) outward or to the left just as the six pairs on the right hand side of FIG. **7** are "fanned" or angled to the right. It will be understood that any "fanning" or angling of air or liquid slots on the left side of the nozzle **10** will be to the left while any "fanning" or angling of air or liquid slots on the right side of the nozzle **10** will be to the right. Adhesive filaments discharging from the liquid slots **150** will fan outwardly generally from the center point of the nozzle **10**, i.e., to the left and to the right as viewed in FIG. **7**, such that the overall pattern width of randomized adhesive filaments will be greater than the width between the two outermost or endmost liquid slot outlets **152** and, desirably, may have a width at least as great as the width of the nozzle **10** itself. It will further be appreciated that any number of the liquid slots **150** may each be gradually fanned or angled outwardly relative to a center point of the nozzle, as shown in FIG. **7**, rather than only the outermost liquid slots **150** having this configuration.

As one additional modification, more than one adhesive shim plate **16** may be used in adjacent, side-by-side stacked format. In this format, adhesive slots in one adhesive shim plate would communicate, respectively, with adhesive slots in an adjacent adhesive shim plate. This would allow, for example, the adhesive slots in each adhesive shim plate to form only a portion of the overall adhesive outlet. If, for example, one or more of the adhesive slots of each adhesive shim plate that communicate with each other is formed with a different shape, a desired overall cross sectional shape for the resulting adhesive filament may be obtained. In this manner, a variety of different adhesive filament shapes may be obtained in different nozzles or along the width of the same nozzle. Cross sectional shapes of the adhesive filaments may, for example, take the form of "plus" signs or "C"-shapes or other geometric configurations.

The discharged stream of pressurized air exiting from each process air outlet **160***a*converges and impacts against a process air stream exiting from each associated outlet **162***a* of the pair **160***a*, **162***a*. In a similar manner, respective process air streams exiting outlets **164***a* impact against the streams exiting from process air outlets **166***a*. This forms a zone of air turbulence directly below each liquid outlet **154** of the nozzle and causes the continuous adhesive filaments **180** exiting the associated liquid outlets **154** to move side-to-side or back and forth in random directions forming an erratic, non-uniform or random pattern as, for example, shown in FIG. **8**. In this regard, FIG. **8** illustrates a substrate **182** onto which the random pattern of multiple, continuous filaments **180** has been deposited after discharge from one or more nozzles constructed in accordance with nozzle **10** as generally described herein.

While the present invention has been illustrated by a description of various illustrative embodiments and while these embodiments have been described in some detail, it is not the intention of the Applicants to restrict or in any way limit the scope of the appended claims to such detail. Additional advantages and modifications will readily appear to those skilled in the art. The various features of the invention may be used alone or in any combination depending on the needs and preferences of the user. This has been a description of the present invention, along with the preferred methods of practicing the present invention as currently known. However, the invention itself should only be defined by the appended claims, wherein what is claimed is:

The invention claimed is:

1. A nozzle for dispensing a random pattern of liquid adhesive filaments, comprising:

first and second process air shim plates, said first and second process air shim plates each having respective pairs of air slots, each air slot having a process air inlet and a process air outlet and said air slots of each pair converging toward one another such that said process air inlets are farther apart than said process air outlets in each pair;

an adhesive shim plate having a plurality of liquid slots each with a liquid inlet and a liquid outlet, said adhesive shim plate positioned between and lying parallel to said first and second process air shim plates such that one of said liquid slots extends generally centrally between a pair of said air slots in said first process air shim plate and a pair of said air slots in said second process air shim plate thereby associating four process air outlets with each of said liquid outlets, said process air slots adapted to receive pressurized process air and said liquid slots adapted to receive pressurized liquid adhesive, each group of said four process air outlets capable of discharging the pressurized process air for moving the filament of liquid adhesive discharging from the associated liquid outlet in a random pattern;

a first separating shim plate positioned between said first process air shim plate and said adhesive shim plate;

a second separating shim plate positioned between said second process air shim plate and said adhesive shim plate; and

first and second end plates secured together and sandwiching said first and second process air shim plates, said adhesive shim plate and said first and second separating shim plates together, said first end plate including a process air inlet communicating with said pairs of air slots in said first and second process air shim plates and a liquid adhesive inlet communicating with said liquid slots in said adhesive shim plate.

2. The nozzle of claim **1**, wherein said first and second process air shim plates have first and second opposite ends, and said pairs of process air slots respectively angle outwardly in a progressive manner from a central portion of each process air shim plate toward said opposite ends of said process air shim plates to assist with spreading the pattern of adhesive filaments outwardly in opposite directions.

3. The nozzle of claim **2**, wherein said adhesive shim plate includes opposite ends and at least said liquid slots closest to said opposite ends of said adhesive shim plate respectively angle outwardly toward said opposite ends.

4. The nozzle of claim **1**, wherein said adhesive shim plate includes opposite ends and at least said liquid slots closest to said opposite ends of said adhesive shim plate respectively angle outwardly toward said opposite ends.

5. The nozzle of claim **1**, wherein said first and second end plates further comprise respective process air passages for directing pressurized process air between said first and second end plates.

6. The nozzle of claim **1**, wherein said first end plate is generally L-shaped and includes a top surface generally orthogonal to planes containing said first and second process air shim plates, said adhesive shim plate and said first and second separating shim plates, and a side surface generally parallel to the planes containing said first and second process air shim plates, said adhesive shim plate and said first and second separating shim plates, said liquid adhesive inlet and said process air inlet formed in said top surface.

* * * * *